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WALKING STICKS.

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Walking Sticks belong to the Order of Orthoptera and are classed under the family Phasmidae, the members of which present a great variety of form. It may be said without exaggeration that the Phasmids exhibit some of the most peculiar, curious objects to be found anywhere in natural history. Among this strange group of insects are those that resemble leaves of trees, lichen-covered bark, stems of grasses and sticks; and so faithfully are these protective characteristics portrayed that an observer may readily be deceived by them even when actually aware of the presence of the insect. It may be worthy of passing notice to mention here that to the Phasmids belong some of the largest insects known. In the Tropics, where both sexes develop wings they attain their greatest size, six inches being a common length.

The particular species to which this paper refers is popularly known by a variety of names such as "stick insect," "stick bug," "specter," "prairie alligator," "devil's horse," "devil's darning needle," etc; the correct name, however, is the thick-thighed walking stick, an appropriate one given by reason of the remarkably dilated femora.

It was during the summer of 1918, while engaged on an oak-borer problem in Queen's Park, Aylmer, Que., ten miles northwest of Ottawa City, that the writer came upon a number of thick-thighed walking sticks, (*Diaperomera femorata* Say), defoliating oak, basswood and hazel. Several specimens were collected for the purpose of making a closer study of the life-history of these extraordinary insects and of obtaining notes on egg records, feeding, general habits and other biologic data. Observations were continued during 1919, and the results of the two seasons work are briefly recorded in this paper.

Ecology. The particular locality where most of the collecting was done was in a thickly wooded lot covered with a mixed growth, for the most part red oaks, but also containing a considerable proportion of maple, ash, basswood, hazel, hickory, ironwood, beech, elm, service-berry and large numbers of sumach and hawthorn. Here small, green, young nymphs of the walking stick were often to be found during June wandering about on the ground over dead leaves and mosses, trying to locate some convenient twig or trunk of a suitable host plant to crawl upon; or, what was more frequent, would be seen on the trunks of the oaks, awkwardly and lazily plodding their way upwards over the roughened bark to the tender, green leaves above, where not only abundant food awaited them, but also excellent protection from enemies was afforded by means of their deceptive colouration. Searching carefully under the large basswood leaves, and by moving quietly among the under growth many specimens of half-grown nymphs

could be located clinging to the twigs and branches, their presence not always being detected at first sight on account of the odd similarity of their long thin bodies and legs to the twigs and branches they were on, a protective resemblance of quite a remarkable character. When disturbed they would often drop suddenly to earth or nervously jerk themselves this way and that; if irritated they exhibited a queer habit of swaying or rolling from side to side, cradle-fashion. Both sexes were taken, but females proved more abundant. Several pairs *in copula* were observed on oak later in the season during August and September.

Egg. This exceedingly odd and interesting object may readily be mistaken for a seed of some kind. In fact one may favourably compare it with that of hemp, so closely does it resemble this product of the vegetable kingdom both in size and shape. It is for the most part black in colour, and highly polished, with a dull whitish keel, shading to olive tints; oval in shape, flattened slightly on the sides and quite hard. At one end is the operculum or capsule, a circular cover which is dark amber in colour, deeply wrinkled and surrounded with a crown of spines, below which a dark oval ring is arranged somewhat obliquely. An oblong scar appears on the whitened area, which is very much like the hilum of a bean.

Nymph. The young nymph is bright green in colour, slow-moving and very awkward. When first hatched the body is about $5/16$ of an inch long, and is of a yellow-green cast; legs and antennae are prominently long and eyes noticeably dark brown. It often happens that some difficulty is experienced in emerging from the egg, and it is not an uncommon sight to find the egg shell attached to one of the hind tarsi being dragged about by the young stick. This may be due to a lack of moisture, for if a drop of water is placed on the shell the creature soon extricates itself. The swaying or rocking habit is very marked in the youngest of nymphs, even those of one day old. As the adult stages are approached, the green tints become tinged with yellow, these again take on a darker shading and tone down to grey-greens, dull-reds, mottled-browns, and dark-greys.

Adults. Generally speaking these insects are long, slim, very narrow, and stick-like in shape. The female is much longer than the male and measures on an average from $3\frac{1}{4}$ inches to $3\frac{1}{2}$ inches in length, and not more than $3/16$ inch broad at the widest part of the abdomen. The head is short and truncate, fits closely to the thorax and at first sight appears to be part of same. The antennae are situated well in front of the eyes and stand upon strong pedestals which are placed widely apart on the head; they are very fine, thread-like organs, of many segments and very long, often exceeding 2 inches; the eyes are large, bulging and strongly rounded; the palpi long, prominent, and conspicuously used while feeding. Not only does the female differ from her mate in length, but her front legs are more dilated, the ridges and grooves on these being more distinctly and deeply marked; the peculiar curve at the base of the front femora which permits the legs to fit very closely to the head is more pronounced than in the male; the middle femora are not swollen as is certainly the case in the male, and the spurs carried on the femora of the second and third pairs of legs are small, insignificant points when compared with those of the male's which are very prominent, sharp and thorn-like, situated near the knee joint. In the female the head and legs are without markings, whereas the male has three

vertical dark-brown stripes on his head and three broad bands of the same colour on the middle femora. Perhaps the thorax is worthy of more than usual attention on account of its extraordinary length. The prothorax, or first division, is very short and bears the first pair of legs which come off from the centre; the second division, or mesothorax, is easily the longest segment in the body, averaging $\frac{3}{4}$ inch; while the third, or metathorax, is a little shorter than the second, in the last two cases the legs being situated at the very extremity of the joints, respectively. The final segment of the male terminates in a pair of pincer-like claspers with which he seizes the female securely when mating.

Copulating habits. Copulation occurs frequently and is often of some duration. *In coitu* the abdomen of the male is ranged at the side of the female in a slanting position, the tip being hooked upward somewhat after the manner in which a scorpion carries its tail, and brought forward to meet the genital opening of the female which is situated on the eighth segment of the abdomen: the claspers seize just above the opening and the union is made immediately. The front and middle pairs of legs are usually employed to grasp the female, while the third pair is extended outwards as a support. The female holds to her resting place chiefly by the second and third pairs of legs. Sometimes one of the front legs will act as a support, say on the side of the cage, while the other hangs out into space. The front pair, however, is often extended straight forward and placed close together appearing as only one member, or spread out widely apart and raised somewhat upwards in much the same attitude as that of the praying mantis, a near relative of the walking stick. Oviposition begins at once.

Oviposition. This occurs in late summer and autumn, from about the middle of August to October. The female walking stick has no interest whatever in her eggs after she has laid them. She scatters them indiscriminately from wherever she happens to be, dropping them from the topmost branches of some oak or from a low coppice to the earth—it is all the same to her,—she has finished with them entirely and neither knows nor cares afterwards what becomes of them. On the ground the majority get covered up in the long grasses or become hidden among the dead leaves, mosses and general debris of the woods at autumn time in this way they receive protection from birds and other enemies until hatching in June.

Oviposition is an interesting performance. When ready to be deposited the egg is slowly pushed down the oviducts to the exterior and as it emerges the egg guides are forced downward to receive it. It glides on to these and is held there as if in a hand, being supported on either side by two finger-like processes. The black and shiny portion lies at the top of the guides and the whitened area with its crease and scar at the bottom. The operculum end appears last. The egg is held about 5 minutes on the guides and when dry the female stirs by walking a step or two, or vigorously jerks her abdomen sideways, sending the egg from her to the ground. From laboratory records this summer, the two females I had confined in cages laid respectively 152 and 141 eggs, at an average rate of three a day. Oviposition was carried on intermittently with copulation, eggs being laid up to within a few hours of the death of the female. Perhaps one of the strangest habits peculiar to some of the females at this time,

when oviposition is at an end, is the withering and splitting of the abdomen much the same as a bean pod will dry, curl and split open.

Females in the late fall may be found in this unfortunate spent condition with strength only left to drag themselves about awhile longer. Some specimens in our collection exemplify this most extraordinary characteristic.

Time of Hatching. Although abundant during 1918 it is worthy of note that throughout the past season, 1919, these insects were exceedingly scarce. Whether this was due to parasites, or weather conditions, or other controlling factors I am unable to say. A close watch was kept throughout the summer for any sign of their activities but I only succeeded in locating one nymph on June 14th, and two pairs of adults and one female on August 13. These last were collected for egg records and I was able to keep them in the laboratory until the beginning of October.

In his Report of Forest Insects for 1878, I find that the late Doctor Riley, of the United States Bureau of Entomology, refers to a communication received from a Mr. Snow, of Yates Co., N. Y., in which the latter states that walking sticks were unusually abundant every other year and that many of the eggs were found to remain on the ground for two consecutive winters before hatching. A further reference in this same report is made to the investigations of Messrs. Bringham and Trouvelot. These gentlemen, writing in the Proceedings of the Boston Society of Natural History, Volume XI, pages 88 to 89, observed that the eggs of the walking stick only hatch after an interval of two years.

Eggs laid in the summer of 1918 and held in storage for winter and spring in a box of sand left exposed to the atmosphere failed to hatch last summer. Those of 1919 were put into glass vials corked with loose cotton batting and left on the laboratory table in a temperature averaging about 70 degrees. On January 28th, 1920, I examined several of these and found them well advanced in their embryonic development. About 18th February, much to my astonishment, a nymph made its appearance in one of the bottles, to be followed by several others at irregular intervals. I had nothing at the time to feed the youngsters on except rock fern (*Pteris* sp.) to which they did not take happily. Later I tried several kinds of green foods, lettuce, tradescantia, geranium, etc., and dried oak leaves soaked in water, but to no avail. The nymphs all died.

Notes on Habits. The Phasmids have been popularly considered harmful and poisonous. Such is not the case. In fact the very reverse is the truth. They are quite harmless, inoffensive creatures, strict vegetarians and easily managed in confinement. One large female, I had in the house for three months and made quite a pet of her. I would often remove her from the cage and allow her to walk over a pot of ferns on the table. She would meander up and down on the green leaves, not attempting to drop to the table or trying to get away. If I put water on the leaves she would immediately take some up and blow it out from her mouth in the form of a bubble, then draw it in and blow it out again, keeping this up for some time, as it were for my amusement. Again I would place her on the table near an electric light. She would walk towards it, hesitate, look around as if uncertain what next to do, then rear herself, spreading out her long front legs to the light, as much as to say "Humph!

I wonder what that is?" and all the time waving her antennae, much the same as a cockroach will do when on the scent for food. After the frost came, killing most of the vegetation, I would gather a few dried oak leaves and soak them in water for her. These she would eat sparingly of, often preferring only to drink up what moisture there might be on the leaf surface. Finally I could get nothing more green for her in the garden and tried a sprig of white pine needles. These she refused. Her egg record dropped to one a day and this only at spasmodic intervals. She was getting weak and helpless. One night I found she had fallen to the bottom of the cage and seemed unable to move. Next morning she was dead.

Walking Sticks are remarkably strong and adhere tenaciously to clothing, netting or roughened surfaces from which it is difficult to remove them without injury, since the legs break easily. Very smooth surfaces are no hindrance to their movements due to the circular white pulvillus, or suction pad on each tarsus, and they will walk up or down the sides of a glass cage quite as easily as on the flat table. Feeding usually takes place at night, and during the day they rest quietly, for the most part at the top of the cage on the cloth covering, head and back downwards. The males spend most of their time *in coitu*, eating little or nothing in confinement. They are the first to die, the females living on for weeks afterwards to deposit their eggs.

Injury. At Aylmer any damage done by this insect so far as I have observed has been negligible. There are, however, localities in the States where the walking stick has proved a serious pest. Mr. Fernald, Economic Zoologist at Harrisburgh, Pa., 1898, reports the appearance of walking sticks near Duncanville Pa., "in countless numbers." The trees attacked were mostly chestnut, oak, and maple, the area of infestation being over one mile long and half a mile wide. Mr. Snow of Yates Co., N. Y., in a letter to Doctor Riley in 1878 relates how walking sticks "had stripped 25 acres of young timber, mostly white oak and hickory, on his reservation."

That such severe infestations as these are likely to occur in Canada I am inclined to doubt, but in the warmer sections, such as Niagara Glen, minor, local outbreaks may take place, as for example that referred to in Ont. Ent. Report, 1904. However, these creatures are very susceptible to cool weather and it is quite possible that the early frosts of the more northern latitudes play a considerable part in their control.

Control. The following control methods have been recommended by Doctor Riley: Poison the vegetation by spraying with Paris green to kill off the very young nymphs and destroy eggs by digging, or burning the grass and vegetation. These appear to be very effective measures but I have had no opportunity so far to test any of them. One female stick in a sickly condition, I secured this summer had eight or ten tachinid eggs on different parts of the body. She refused all food and died two days after being brought into the laboratory, the body becoming quite limp and withered. I kept the specimen in a vial for closer examination, but no evidence of parasites was observed so concluded that their life cycle had been interrupted by the death of the host-which perhaps was brought about by some other agency than the fly itself.